PROBLEM 6-16N Question

Tokamak Power Generation Problem

A problem associated with Tokamak fusion reactors is that power generation is intermittent and some type of energy storage device is required to maintain a constant electrical generation rate. One suggested solution to this problem is a combination steam generator/steam storage unit which expands in volume (at constant pressure) during the reactor "burn," and contracts to its original volume during the reactor down time. The Tokamak and the power cycle are given in Figure 1. Relevant physical properties and conversion factors are given in Table 1.

The Tokamak reactor burn cycle is 1000 seconds at 6680 MWt. The down time at zero power is for 100 seconds after which the power cycle is repeated. This reactor power cycle is illustrated in Figure 2.

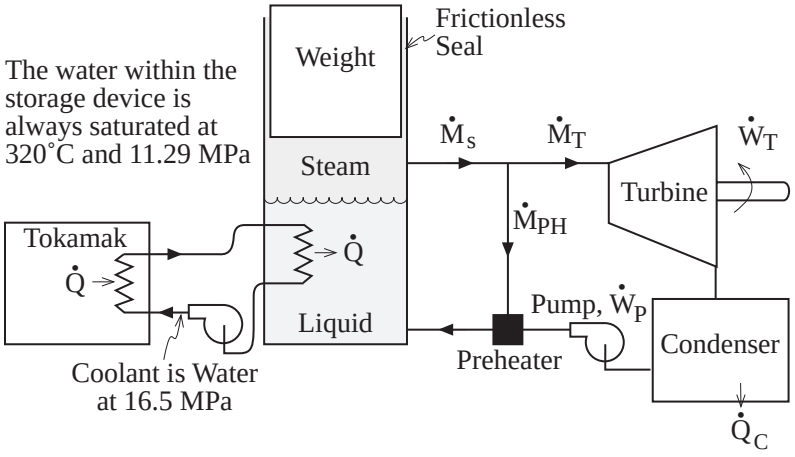

Figure 1 Tokamak and Power Cycle

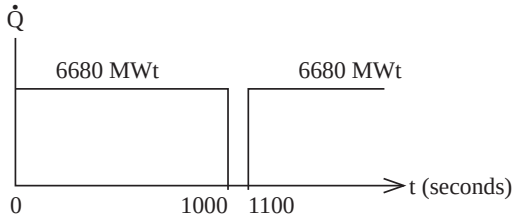

Figure 2. Reactor Power Cycle

TABLE 1. Property Data for 320˚C, 11.27 MPa

		Water, f	Steam, g	Water To Steam, fg
v	m^3/kg	$1.5x10^{-3}$	0.015	0.0135
h	kJ/kg	1462	2700	1238
u	kJ/kg	1445	2526	1081
c_p	kJ/kg˚K	6.604	8.060	
σ	N/m	$9.89x10^{-3}$	--	
μ	Ns/m^2	$83.5x10^{-6}$	$20.95x10^{-6}$	
k	W/m˚K	0.503	$87.8x10^{-3}$	
Pr		1.11	1.92	

Unit Conversions:

J = Nm = Ws

Pa = N/m^2

QUESTION

The liquid mass in the steam generator/storage unit necessary to cover the heat exchanger tubes is $3.6x10^6$kg and the quality at the start of a reactor burn is 15%.

a) Sketch a graph of steam mass stored in the steam/generator/storage unit versus time, and of the liquid mass stored in the steam generator/storage unit versus time. Explain the basis for your sketches.

b) Calculate the required total volume of the steam generator/storage unit.